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(54) AN AIR-CONDITIONING SYSTEM FOR A ROOM

(71) We, MESSIER of 6 Avenue Raymond Poincare, 75 Paris 16e, France and ENTREPRISE HENRI FAURE of 111 Avenue Jean Jaures, 92 Montrouge, France, both bodies corporate organised and existing under the laws of France, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention concerns an air-conditioning system for a room to house a computer.

Previously proposed systems have used two assemblies of conditioning apparatus, one of them serving to cool the computer and the other to air-condition the room.

It can be seen that system systems require the use of two separate regulating assemblies, therefore two control blocks, that is to say one block per conditioning circuit. To provide effective functioning, it is often necessary also to provide efficient regulation of and interaction between the above-mentioned two systems, and to provide for pre-heating of the computers before they are put into operation. Moreover, the room in which the computers are housed must necessarily be of a given, often considerable, height, to ensure good conditioning results. Finally, opening a door or doors of the room, for example to permit staff or equipment to pass, disturbs the systems and the work which is being done.

According to the invention there is provided an air-conditioning system for a room which localises, in a turbulence zone below the ceiling of the room, turbulence effects due to the supply of fresh air to the room and the removal of the stale air therefrom, thus providing for persons in the room an environment of calm air below said turbulence zone, the system comprising an air-conditioning plant and a device for regulating the pressure and/or the supply of fresh air, cooperating with means for introducing conditioned air through first apertures located near or below the ceiling and for extracting stale air through second apertures also located near or below the ceiling and further cooperating with a simple circuit for blowing air and recycling same, said simple circuit being located in a lower part of the room and a part of said simple circuit being formed by a cabinet of a computer.

The operation of such a system can be very simple since it requires only a single regulating device. By arranging for continuous function of the circuit which recycles the air, it becomes possible to maintain the ambient temperature in the room and the temperature of the computer at levels such that the computer can be put into operation almost immediately, even after having been stopped for a prolonged period, assuming that the room is heated normally.

In accordance with a particular embodiment of the invention, the assembly comprising the air-conditioning plant and the regulating device is preferably but not necessarily disposed in another room isolated from the computer room by a sealed partition and communicates through a conduit housed in a space between the ceiling and a false ceiling of the computer room, with nozzles, forming said second apertures, for blowing fresh filtered air into the room, which nozzles are disposed in the false ceiling, and, by means of said space which terminates in the separating partition, with said second apertures for the extraction of stale air, which second apertures are pierced in the false ceiling.

The number of said second apertures is preferably larger than the number of nozzles and their section and distribution depends on the conditions of operation such as the volume of the room, its height and the characteristics of the air-conditioning plant.

Vanes are preferably provided adjacent the blowing nozzles and are inclined so that the direction of the flow of air discharged into the room through the vanes, is at a relatively small angle to the plane of the false ceiling.

By virtue of the particular features mentioned above, and other features which will

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be specified hereinafter, the turbulence zone created by the discharge of the fresh air supply is located in the highest part of the room and consequently does not trouble staff operating the computer.

The blowing speed of the fresh air can therefore be made relatively high, to ensure rapid renewal of the air in the room, without causing any inopportune and violent flow in the vertical or horizontal direction.

Since the pressure in the lower part of the room is static, all stirring up of air takes place in the zone of turbulence. The opening of a door or doors of the room therefore has an effect only on the turbulence zone and consequently does not give rise to any violent displacement of air which might disturb the staff.

In accordance with an advantageous embodiment of the invention, a mattress of heat and sound insulating material such as glass wool is placed on the upper face of the false ceiling. When the air-conditioning plant is not in operation, the mattress rests on the upper faces of the false ceiling. In this case, the mattress acts as a valve as it blocks the extraction apertures. The time for heating the air in the room, to an acceptable temperature when starting up from a closed-down condition, by operation of the simple circuit for blowing and recycling air and the computer alone, is consequently reduced. When the air-conditioning plant comes into operation, the mattress is lifted by the extraction action of the air-conditioning plant and leaves a passage for the hot stale air between the upper face of the false ceiling and the mattress. In this case the mattress acts as heat insulation and as a sound insulation, reducing the sound level of the air extraction and supply by the air-conditioning plant. When a door of the room is opened, the mattress drops down again and blocks the induction openings, thus reducing the effect of the door being opened on the turbulence zone.

In one embodiment of the invention, the simple circuit for blowing and recycling air comprises a recycling apparatus which is also disposed in the room and which is intended to draw in through the partition the air in the room and to discharge it, below a false floor of the room, towards the computer through the cabinet of which it passes by way of the base and issues therefrom by way of the top.

Advantageously, the recycling apparatus comprises a blower drawing air from the room through a grating disposed in the partition at a height above the false floor of the room which is approximately equal to half the height of the computer.

Discharge of the stale air issuing from the operating zone, that is to say from the part below the turbulence zone, is accelerated and aided by the means for blowing and recycling air through said simple circuit.

In another embodiment of the invention, the false floor is constructed of removable slabs and the means for flowing and recycling air is dimensioned so that it can replace any one of the slabs.

The invention is diagrammatically illustrated by way of example in the accompanying drawings, in which:—

Figure 1 is a vertical section through a room housing a computer and an air-conditioning system according to the invention;

Figure 2 is a partial vertical section of the false ceiling of the room of Figure 1, showing the position of a sound insulating mattress when the air-conditioning plant is not in operation;

Figure 3 is a view similar to Figure 2, but showing the position of the sound insulating mattress when the air-conditioning plant is in operation;

Figure 4 is a partial vertical section of the false ceiling of Figure 1 showing the action of the inclination of vanes on the direction of the flow of air discharged into the room; and

Figure 5 is a partial vertical section showing an arrangement of a false floor with removable slabs, according to another embodiment of the invention.

Figure 1 shows a room 1 housing a cabinet of a computer 2. The room 1 has a false floor 3 constructed at a height h_1 above a lower floor 4 and a false ceiling 5 located at a distance h_2 below an upper ceiling 6. The reference h_3 denotes the height between the false floor 3 and the false ceiling 5. This is the height available to house the computer and the operating staff.

Air-conditioning plant 7 to condition the air of the room 1 and recycling apparatus 8 to ventilate the cabinet of the computer 2 are disposed in a room 9 which is preferably separated from the room 1 by a sealed partition 10. The air-conditioning plant 7 passes air into the room 1, as shown by arrows f_1, by way of a conduit 11 and nozzles 12 disposed in the false ceiling 5. The pressure in the room is preferably maintained at a pressure P_1 which is slightly higher than atmospheric pressure P. As shown in Figures 2, 3 and 4, each of the nozzles 12 is provided with a filter 13 and vanes 14 are disposed in the false ceiling 5 downstream of the nozzles.

The vanes 14 are each advantageously inclined so that the jet of air discharged into the room is at a relatively small angle α to the false ceiling 5. The warm and stale air from the room is drawn off by the air-conditioning plant 7 through a large number of small openings 15, as shown by the arrows f_2, pierced in the false ceiling 5. The shape and in particular the area of the cross-section of

each opening 15, and also the distribution of these openings, depends on the particular operating conditions, for example the volume of the room 1, its height h_3 and the characteristics of the air-conditioning plant 7. Generally, the total surface area of the openings 15 should lie between 8% and 15% approximately of the surface area of the false ceiling 5. Excellent results have been obtained with circular openings which are from 4 to 8 mm in diameter and which are regularly distributed with a density of from 4 to 1 openings per sq.cm., depending on the section of opening selected.

Stale air flows into the space between the ceiling 6 and the false ceiling 5 and then into a conduit 16 which begins below the ceiling 6, at the separating partition 10, and passes through a device 17 for regulating the pressure and/or supply of fresh air, the device 17 being of known kind.

A mattress 18 formed of sound insulating material such as glass wool, preferably encased in an envelope of plastics material, is placed on the upper face of the false ceiling 5, as shown in Figure 2. The action of this mattress will be described in greater detail hereinafter.

Recycling apparatus essentially comprises a blower 19 to draw in stale air from the room by way of a grating 20 disposed in the partition 10 at a height h_4 above the false floor 3, whereby h_4 is approximately equal to half the height h_2 of the cabinet of the computer 2. The height h_4 should preferably be from 0.30 m to 1.20 m. The blower 19 discharges air through a filter 21, through the space below the false floor 3 into the base of the cabinet of the computer 2, and issues therefrom at its top, following the arrow f_2.

Operation of the air-conditioning system described above is as follows:

Two modes of operation for the installation can be envisaged: a first mode which is applicable when the ambient temperature in the room 1 is either lower than 18°C or higher than 24°C and a second mode which is applicable for an ambient temperature in the room of from 18°C to 24°C.

In the first mode of operation, the air-conditioning plant 7 is operated either to cool or to heat air, until the temperature in the room reaches a value between the above mentioned limits, when the second mode of operation is brought into effect. It is essentially the air-conditioning plant which serves to condition the room.

In the second mode, only the computer 2 and the recycling apparatus 8 are initially set in operation. The blower 19 draws in the air at a temperature t from the room by way of the grating 20 and discharges it by way of the filter 21 into the base of the cabinet of the computer 2 at a temperature $t_1=t+\Delta t$ in which the Δt is the very small increase in temperature due to the heat given off by the blower 19. The air at the temperature t_1 passes through the computer 2 which is in operation and which gives off heat. The air then leaves the computer at a temperature $t_1+\Delta t_1$ and is again drawn in by the blower 19. The temperature of the computer and the temperature of the room progressively rise until the normal operating temperature of the computer on the one hand and an acceptable temperature in the room on the other hand are reached. It has been found that a temperature of about 21°C is acceptable both as regards the computer and as regards comfort of operating staff for the computer.

In the second mode, the air-conditioning plant 7 is set in operation only when the acceptable temperature is reached. It then extracts hot and stale air through the openings 15, the space between the ceiling 6 and the false ceiling 5, the conduit 16 and the fresh air supply device 17. The device 17 only operates if there is a drop in pressure in the room. As soon as the air-conditioning plant 7 is set in operation, the mattress 18 is lifted by the air drawn through the openings 15 and provides a passage for the hot stale air between the upper face of the false ceiling 5 and the mattress 18 (see Figure 3). When the air-conditioning plant 7 is not operating, the mattress rests on the upper face of the false ceiling (see Figure 2). The mattress 18 therefore functions as a valve and as a sound-insulating barrier. During the period that the room and the computer are being raised to the operating temperature, for an initial temperature of from 18°C to 24°C, the openings 15 remain closed by the mattress 18. Leakage is therefore greatly reduced and the time taken to reach desired operating conditions is decreased. When the air-conditioning plant 7 is operating it draws air from the space between the ceilings 5 and 6 which raises the mattress 18 and allows the stale air to pass; it then acts as a heat insulation and also as a sound insulation since it tends to reduce the observed sound level of induction and discharge of air by the air-conditioning plant 7. The mattress 18 can also equalise the flow of air drawn in by the air-conditioning plant 7, by promoting the formation of a laminar flow.

As mentioned above, there is obtained in the room 1 a pressure $P_1=P+\Delta P$ which is slightly higher than atmospheric pressure P. The air-conditioning plant 7 supplies conditioned air through the blowing nozzles 12 at a pressure $P_1+\Delta P_1$, ΔP_1 being the increased pressure necessary to take into account the losses in the feed conduits to the nozzles and in the nozzles themselves. The device 17, by supplying fresh air and/or increasing pressure, provides for compensation of pressure leakage S through the walls of the room, operating

variation of the computer and charge losses in the various passages.

The air under pressure issues from the nozzles 12 by way of the vanes 14 inclined at an angle α to the plane of the false ceiling (Figure 4). Tests have shown that the use of an angle α of about 7° is particularly advantageous to ensure, for example at a blowing speed of 6 m/s, that air passes into the highest part of the room 1 in which the air creates a turbulence zone Z of which the height is h_z. The latter height must be such that the service height h_s of the room is sufficient to permit the staff operating the computer to work easily. For example, for a room with a height h_s of 2.40 m, the height h_z must be L 0.60 m approximately.

The formation of this turbulence zone Z is due mainly to the following factors:

—blowing and extraction which are effected at the level of the false ceiling 5; owing to the blowing action, a diffusion effect is created which results on the one hand from injection of air by the nozzles 12 and on the other hand from extraction of the hot stale air by way of the openings 15;

—the speed of the air flow at the level of the openings 15 owing to the local action of the increased pressure ΔP;

—the movement of the hot air issuing from the different heat sources towards the zone Z.

It is in the turbulence zone Z that heat exchange action occurs. It is also in this zone that there occurs automatic pre-regulation of pressures so as to produce a regular pressure $P+\Delta P$ in the operating zone of which the height is h_s, and regulation of the air pressure and thus the air flow speed at the level of the nozzles. The height h_z is determined in dependence on the total height of the room, $h_s=h_s+h_z$, the desired discharge pressure P_r, the inclination of the vanes, the dimensions and density of distribution of the openings 15. The above-mentioned diffusion effect and the consequences thereof tend to reduce the height h_z of the zone Z.

To sum up, operation of the air-conditioning plant 7 causes on the one hand a discharge of conditioned air from the nozzles 12 towards the operating zone of the room, and on the other hand, re-induction towards the nozzles and extraction of stale air by way of the openings 15.

The discharge of stale air from the operating zone h_s of the room is accelerated by the recycling apparatus 8. As mentioned above, the induction grating 20 of the blower 19 opens into the room at a height h_3, which is substantially equal to half the height h_s of the cabinet of the computer 2. This arrangement is advantageous. In fact, the atmosphere in the room 1 during operation of the computer can be considered as being divided into at least three zones of which the temperatures increase slightly from the false floor 3 to the zone Z.

A first zone of which the height is slightly greater than h_1 and the temperature of which is of the order of 21°C.

A second zone of which the height is approximately equal to the height of a man. The temperature of this zone is slightly higher than that of the first zone and is preferably such that the operating staff feel comfortable; this temperature can be of the order of 22°C.

A third zone in which the temperature is higher, for example 23°C, and in which the hot stale air issuing from the various heat sources accumulates. Above this third zone is the turbulence zone; the temperature in this zone is indeterminate but is lower than that in the lowest zone.

The three zones located below the zone Z are mixed and re-constituted continually under the effect of leakages S, the increased pressure ΔP and the closed circuit drawing action of the recycling apparatus 8 so that an average temperature, t=21°C for example, is produced in the operating portion of the room. This intermixing of the different layers occurs at a very low speed. In spite of a high rate of intermixing, defined as being the ratio of the blown air flow to the volume of the room, there is no inopportune and violent flow in the horizontal direction, and the occupants of the room do not have any sensation of "wind" below the zone Z.

Finally, by virtue of continuous operation of the recycling apparatus 8, when the computer 2 and the air-conditioning plant 7 are stopped, the ambient temperature of the room and the temperature of the computer can be maintained at values such that the computer can be put into service almost immediately, even after a prolonged stoppage.

An embodiment of the invention was described hereinbefore (mainly with reference to Figure 1, in which the recycling apparatus 8 is fixed; it can, however, be movable, as shown in Figure 5 in which the same members bear the same references. In this case, the false floor 3 is formed by a plurality of removable slabs 31 which are simply placed in a squared-off arrangement on longitudinal beams 32 and the recycling apparatus 8 is movable: a slab 31 has only to be removed and replaced by the apparatus 8; the cabinet of the computer 2 can be given the same mobility; thus the working position or positions can be organised in accordance with the particular needs or preferences of the moment, and they can be modified whenever desirable.

A practical embodiment is given hereinafter:

—available height $h_3=h_2+h_5=2.30$ m
—height of the false floor $h_1=0.30$ m
—height of the false ceiling $h_2=0.20$ m
—height of the turbulence zone $h_4=0.50$ m
—environment blowing (air-conditioning plant): 7,000 m^3/h
—blowing below the computer (recycling): 3,000 m^3/h
—recovery (induction into the false ceiling): 6,500 m^3/h
—rate of complete air change in the room: 23 times/h
—temperature $t=21°C$.
—temperature $t_1=t+\Delta t=21.3°C$.

WHAT WE CLAIM IS:—

1. An air-conditioning system for a room which localises, in a turbulence zone below the ceiling of the room, turbulence effects due to the supply of fresh air to the room and the removal of the stale air therefrom, thus providing for persons in the room an environment of calm air below said turbulence zone, the system comprising an air-conditioning plant and a device for regulating the pressure and/or the supply of fresh air, cooperating with means for introducing conditioned air through first apertures located near or below the ceiling and for extracting stale air through second apertures also located near or below the ceiling and further cooperating with a simple circuit for blowing air and recycling same, said simple circuit being located in a lower part of the room and a part of said simple circuit being formed by a cabinet of a computer.

2. An air-conditioning system according to claim 1, in which the air-conditioning plant and the regulating device communicate, through a conduit housed in a space between the ceiling of the room and a false ceiling of the room, with nozzles, forming said first apertures, for blowing filtered air into the room, which nozzles are disposed in the false ceiling and cooperate with inclined vanes, and also communicate, by way of said space, with said second apertures which are pierced in the false ceiling for extraction from the room of the stale air, and in which a mattress of heat and sound insulating material, such as glass wool, is placed on the upper face of the false ceiling and forms a valve for the openings for extraction of stale air.

3. An air-conditioning system according to claim 1 or claim 2, in which said means for blowing and recycling air through a simple circuit draws in, by way of a grating, air from the room, at a level equal to half the height of the cabinet of the computer, and discharges it by means of a blower, through a filter, under the false floor of the room to enter the base of the cabinet of the computer.

4. An air-conditioning system according to claim 3, in which the false floor is formed by a plurality of removable slabs, in a squared-off arrangement supported by longitudinal members, said means for blowing and recycling air being dimensioned so that it can replace any one of the slabs.

5. An air-conditioning system for a room substantially as hereinbefore described and illustrated with reference to Figures 1 to 4 or Figures 1 to 4 as modified by Figure 5 of the accompanying drawings.

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1320534 COMPLETE SPECIFICATION
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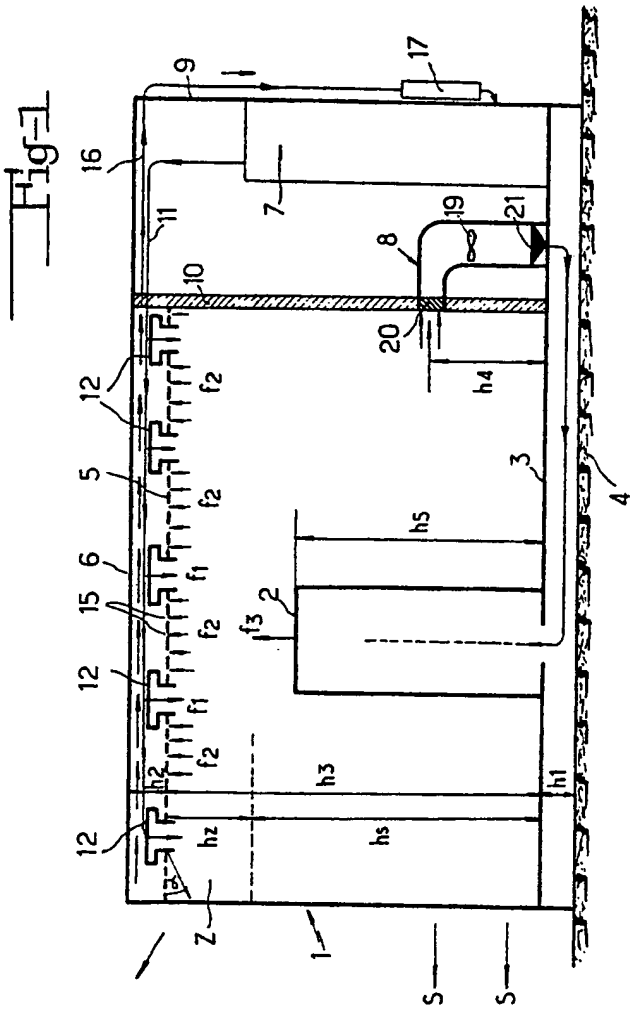
Sheet 1

Fig-1



1320534 COMPLETE SPECIFICATION
2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 2

Fig-1

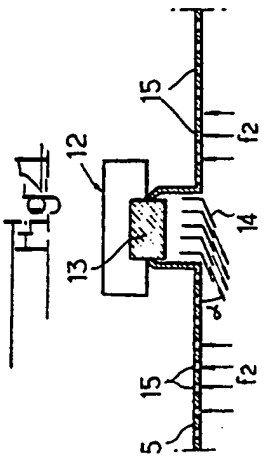


Fig-5

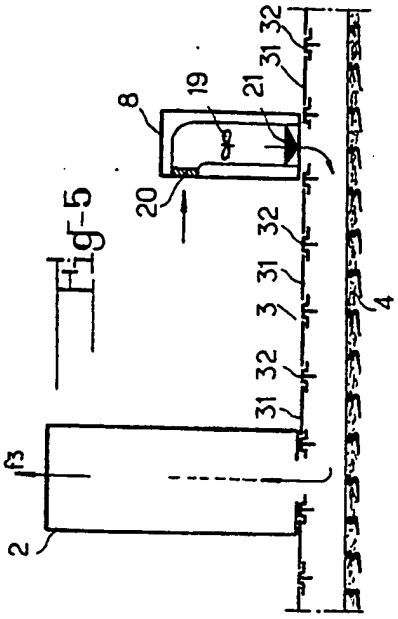


Fig-2

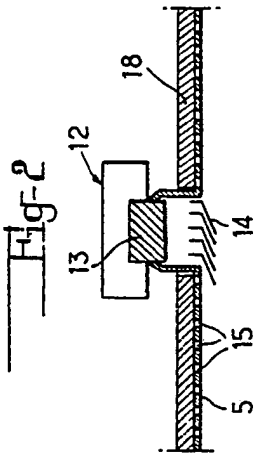


Fig-3